Key drivers controlling daily stable isotope variations in precipitation of Costa Rica: Caribbean Sea versus Eastern Tropical Pacific Ocean moisture sources

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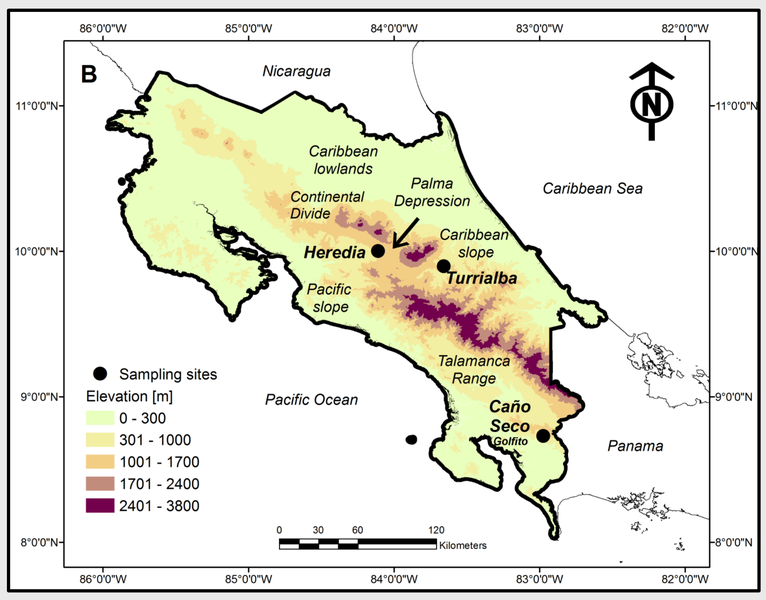
I. Introduction

Costa Rica is located on the Central American Isthmus, which receives moisture inputs directly from the Caribbean Sea and the Pacific Ocean. While this location includes unique mountainous and lowland microclimates, only limited knowledge exists about the impact of relief and regional atmospheric circulation patterns on precipitation origin, transport, and isotopic composition.

This study examined daily isotopic variations at three strategic locations in Costa Rica for the year 2013: Heredia (Central Valley, which receives moisture inputs from both the Pacific and Caribbean), Turrialba (Caribbean Slope), and Caño Seco (South Pacific Slope). Isotope ratios were analyzed in combination with surface and convective meteorological data and HYSPLIT back air mass trajectories **to i) investigate whether key drivers of isotopic variability can be identified, and ii) determine spatial patterns of parental moisture sources.**

II. Study Area



II. Methods

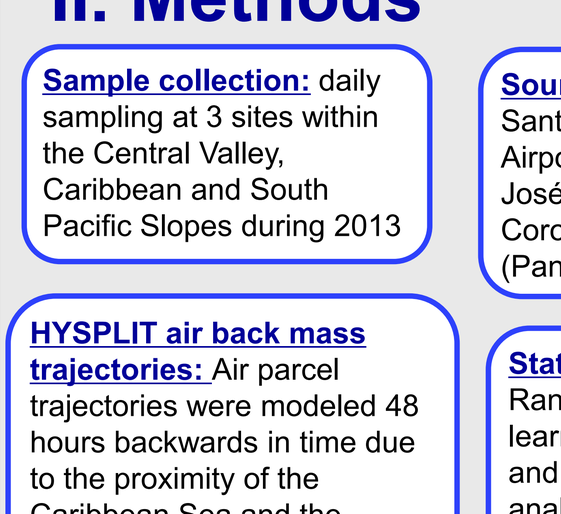
Sample collection: daily sampling at 3 sites within the Central Valley, Caribbean and South Pacific Slopes during 2013

Sounding profiles: Juan Santamaría International Airport 78762 MROC (San José, Costa Rica) and Corozal 78807 MPCZ (Panamá Canal).

HYSPLIT air back mass trajectories: Air parcel trajectories were modeled 48 hours backwards in time due to the proximity of the Caribbean Sea and the Pacific Ocean

Statistical analysis: Random Forest machine learning tool, correlation and linear regression analyses

III. Climate generalities

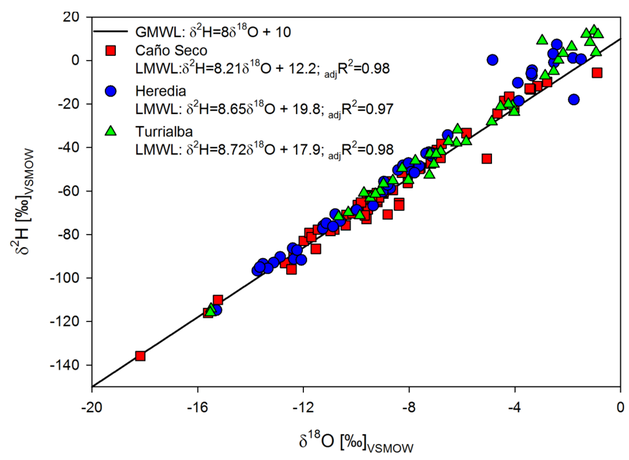


Climate of Costa Rica is mainly controlled by:

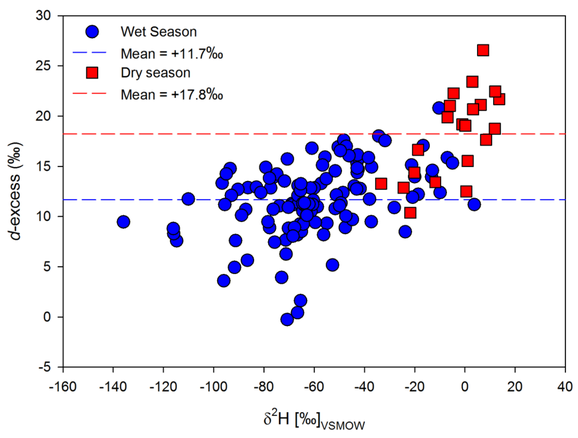
1. Northeast trade winds (i.e. alisios),
2. The latitudinal migration of the Intertropical Convergence Zone (ITCZ)
3. Cold continental outbreaks (i.e. northerly winds or nortes)
4. Sporadic influence of Caribbean cyclones

IV. Results

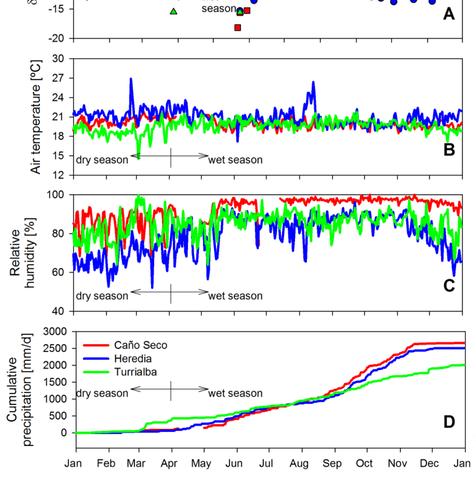
4a. Local meteoric water lines



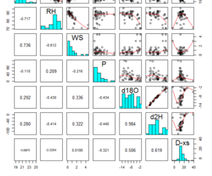
4b. *d*-excess (dry versus wet season)



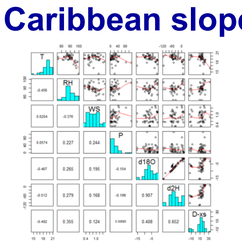
4c. $\delta^{18}O$ temporal variations and bivariate analysis



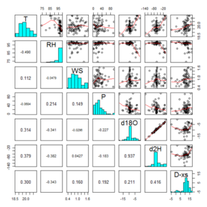
Central Valley



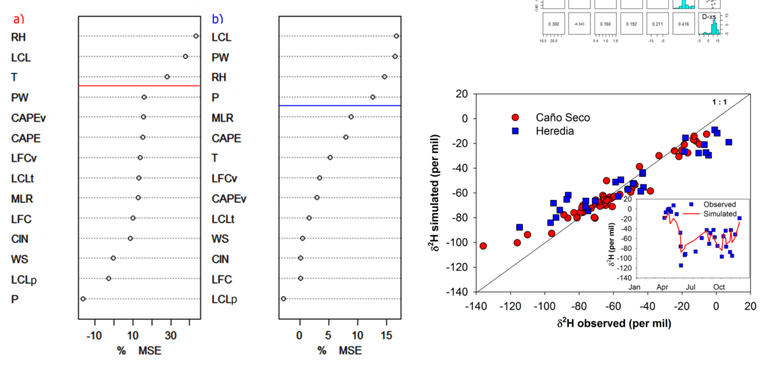
Caribbean slope



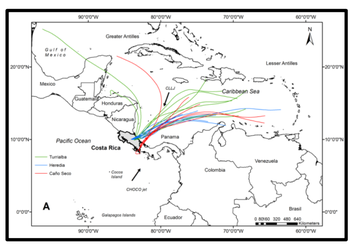
South Pacific slope



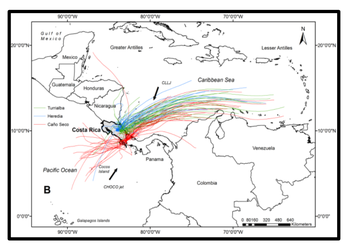
4e. Random Forests learning tool



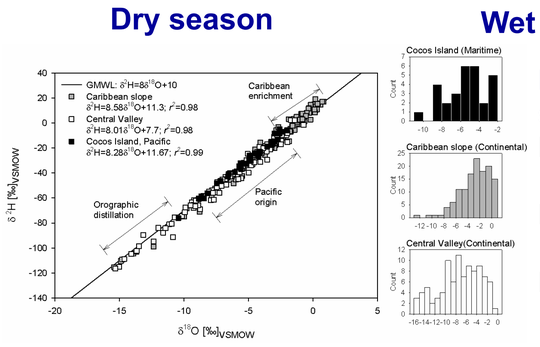
4f. HYSPLIT trajectories



Dry season



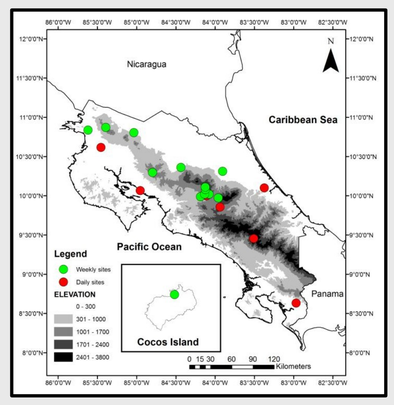
Wet season



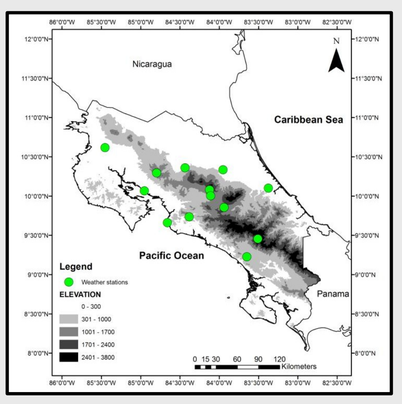
Isotope separation:

I. Caribbean source
II. Pacific Source
III. Orographic distillation

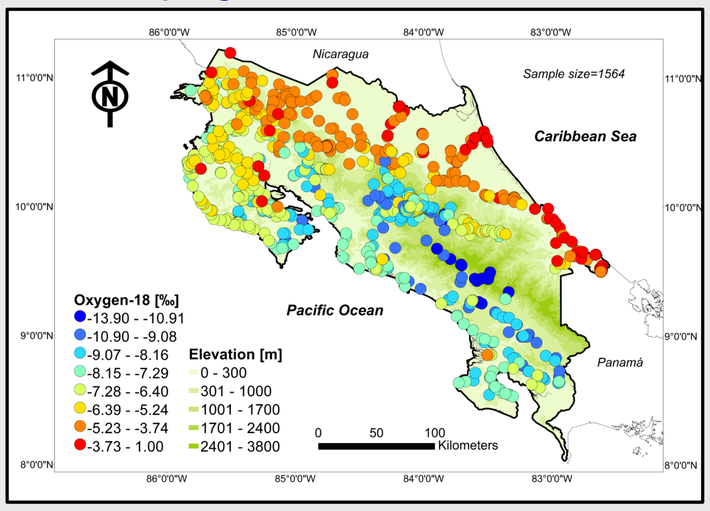
V. Current research



7 daily and 12 weekly rainfall sampling sites



13 weather stations



Building an isoscape (surface and groundwater) for Costa Rica

VI. Concluding remarks

1. Contrary to the previously reported monthly 'amount effect', **precipitation volume plays a rather minor role explaining daily isotope variability in tropical meteoric waters**.
2. By far the most important drivers (as assessed by Spearman rank correlation and Random Forests MLR analyses) were **the Lifted Condensation Level and relative humidity. Both variables explained over 70% of the variance in MLR models.**
3. Together with HYSPLIT back air mass trajectories we were able to further relate **the diverse origin of moisture and transport mechanisms to the observed daily isotopic variability.**
4. The results of this study can be used to predict the daily isotopic composition in precipitation elsewhere in the region with implications for water resource management. **The latter could be informed towards the likely origin of rainfall recharging groundwater and the aquifer's susceptibility to drought induced by a prolonged Pacific dry season.**

VII. Acknowledgments

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